REMARKS

Claim Rejections Under 35 USC § 103

Claims 1 - 4, 6, 9 - 12, and 21 - 25 are rejected under 35 USC § 103(a) as being unpatentable over U.S. Patent No. 5,849,639, to Molloy et al. ("the Molloy reference").

Applicants respectfully contend that the disclosure in the Molloy reference does not render applicants' invention obvious. All of the cleaning methods described in the Molloy et al. reference require the use of a water rinse to complete the cleaning of the semiconductor surface. Applicants' method does not require a wet surface treatment of any kind. In addition, the process described in the Molloy reference is carried out at process chamber pressures in the range of 0.7 - 1.5 Torr , which indicates to one skilled in the art that the plasma used in the process disclosed in the Molloy reference is not likely to be a high density plasma. Applicants specifically describe and claim the use of a high density plasma in their post etch treatment process.

In more detail, the Molloy reference describes the use of a plasma generated from a combination of gases to treat an etched semiconductor structure, to remove a photoresist layer, and to alter the composition of the residues present on the etched substrate surface, so that the residues become soluble in water and can be rinsed off using deionized water. (Abstract) All of the cleaning methods described in the Molloy et al. reference require the use of a water rinse to complete the cleaning of the semiconductor surface. By contrast, applicants' dry plasma treatment method achieves sufficiently complete removal of residues that no post-treatment water rinse or other wet chemical treatment step is required.

The Examiner has argued that applicants' claims do not exclude a rinsing step following the dry plasma process. However, applicants' disclosure clearly states that the complete post-etch treatment (PET) is at least one and may be a series of plasma treatment steps, which remove the etch residues and polymeric materials. Please see Specification Page 4, lines 16 - 22. In addition, the PET is illustrated in Fig. 5 to include only dry plasma treatment steps. Applicants repeatedly teach that the PET is preferably carried out in the same processing chamber as the dielectric etch. Please

see Specification Page 4, lines 19 - 20; Page 10, lines 5 - 6; and Page 10, lines 12 - 13, for example. A wet, deionized water treatment would not be carried out in a plasma etch chamber.

To make it clear that the entire post-etch treatment is a dry plasma process, applicants have added a whereby clause to independent Claims 1 and 13 as follows: "whereby etch residues and polymeric deposits are removed from a surface of said semiconductor structure". This whereby clause is supported at Specification Page 4, lines 16 - 22 and at Specification Page 11, lines 13 - 17, which clearly teach that the PET is performed using only plasma treatment to effectively remove residues and polymers which remain on the substrate surface after the dielectric etch. Applicants' method does not require a wet surface treatment to remove the residue. There is no suggestion of applicants' invention in the Molloy disclosure, which teaches away from applicants' totally dry plasma cleaning technique

The process described in the Molloy reference is carried out at process chamber pressures in the range of 0.7 - 1.5 Torr (700 mTorr to 1,500 mTorr) as indicated at Col. 5, lines 6 - 27. this indicates to one skilled in the art that the plasma used in the process disclosed in the Molloy reference is not likely to be a high density plasma. Applicants' post etch treatment for removal of etch residues and polymeric materials is specifically carried out in a high density plasma (Specification Page 9, line 27 through Page 10, lines 1 - 3.), at pressures ranging from 20 mTorr to 120 mTorr when there is a flushing step, and at pressures ranging from about 20 mTorr to about 50 mTorr when there is a PET without a flushing step. (Please see Specification Page 11, lines 6 - 12 ,and Page 12, lines 18 - 24.)

In light of the above distinctions, applicants respectfully request withdrawal of the rejection of Claims 1 - 4, 6, 9 - 12, and 21 - 25 under 35 USC § 103(a), over Molloy et al.

Claims 1 - 30 are rejected under 35 USC § 103(a) as being unpatentable over U.S. Patent No. 6,082,374, to Huffman et al. ("the Huffman reference"). Since Claims 19 and 20 were previously

cancelled from the application, applicants believe that the Examiner intended the subject rejection to be directed against Claims 1 - 18 and 21 - 30.

Applicants respectfully contend that the Huffman et. al. reference does not render applicants' invention obvious. The Huffman reference recommends the use of plasma processing conditions which will not produce a high density plasma; recites the use of a specialized sapphire plasma tube in all embodiment descriptions and claims; and, requires removal of the substrate from the processing chamber for a rinse step to remove soluble residues which have been created on the substrate by the plasma treatment. Applicants' invention describes and claims the use of a high density plasma to provide a dry surface treatment which removes residues by the plasma treatment alone. The Huffman reference is not enabling for and does not even suggest the series of processing steps described and claimed by applicants. The Huffman reference describes a different method, carried out using different equipment and processing conditions, and achieving different results than those achievable using applicants' presently claimed invention.

In more detail, in the Huffman et al. disclosure, the plasma is generated in a sapphire discharge tube, and plasma from the tube is "directed toward" the substrate. Figures 33 and 34 illustrate how the plasma described in the Huffman reference is generated remotely from the process chamber in which the substrate is present. This is described at Col. 10, lines 11 - 33, in which: " Fig. 33 shows a more complete device as assembled. Magnetron 60 provides microwave power, which is fed through coupler 62 to a waveguide . . . . .. The bottom plate of waveguide section 66 in FIG. 33 is iris plate 50, which couples microwave energy into partitioned microwave structure 42, through which the plasma tube extends, thus, a plasma is excited in the gas flowing through the plasma tube. . . . . The other end of the plasma tube is located in end member 80, and has an orifice 86 for emitting gas into the process chamber.

The process chamber 84 includes retractable wafer support pins 90 and 91 which support wafer 88, to be processed. Chuck 92 is for providing the correct heating to the wafer during processing."

Applicants' apparatus employs inductively coupled plasma generation within the process chamber in which the substrate is contained. A high density plasma is formed directly over the surface of a substrate being treated. In applicants' apparatus, which is illustrated in applicants' Figure 9, RF power is applied to coils to generate the high density plasma in the processing chamber, where the pressure typically ranges from about 20 mTorr (0.020 Torr) to about 120 mTorr (0.120 Torr).

Applicants' independent Claims 1 and 13 recite a high density plasma as defined in their application, where the plasma exhibits an ionization density of at least 10^{11} e^- / cm^3. On Page 4 of the present Office Action, the Examiner acknowledges that the Huffman reference does not teach using a plasma with an electron density of at least 10^{11} e^- / cm^3.

The plasma density of the plasma described in the Huffman reference at the surface of the substrate is not specifically defined. However, the only pressure suggested in the Huffman et al. reference for the process chamber is 1.5 torr; this in combination with the example information provided with reference to the conditions for treatment of the substrate indicate to one skilled in the art that the substrate is not contacted with a high density plasma.

In his Office Action, the Examiner argues that Huffman teaches at Col. 6, lines 11 - 13 that the chamber pressure may be as low as a few mTorr. However, it is important to distinguish between the pressure in the plasma generation and discharge device and the pressure in the substrate processing chamber. At Col. 5, lines 29 - 32, the Huffman et al. reference teaches that the pressure in the plasma tube ranges from about 0.5 torr to about 10 torr, but the pressure in the process chamber is most preferably about 1.5 torr. At Col. 6, lines 11 - 13, the Huffman et al. reference teaches that the pressure maintained in the plasma generating and discharge device is from a few millitorr to about 10 torr. In the Examples 1 - 4, it is not clear whether the pressure described is the pressure in the plasma generation and discharge tube or the pressure in the processing chamber; however, this does not matter since the pressure given is 1.5 torr. Further, the Huffman reference does not describe any combination of process conditions, including plasma source gas composition,

which may be used at process chamber pressures in the range of a few millitorr.

As discussed in applicants' previous Amendment "B", the Huffman reference teaches the use of a deionized water rinse to remove the last residues from the substrate (Col. 3, lies 39 - 43) after the plasma treatment of the substrate. By contrast, applicants' method achieves sufficiently complete removal of residues that no post-treatment water rinse or other wet chemical treatment step is required.

As previously mentioned, with respect to the distinctions from the Molloy reference, applicants' disclosure clearly states that the complete post-etch treatment (PET) is at least one and may be a series of plasma treatment steps, which remove the etch residues and polymeric materials. Further, applicants repeatedly teach that the PET is preferably carried out in the same processing chamber as the dielectric etch, and a water rinse would not be carried out in the etch chamber.

In light of the above distinctions, and the addition of the previously discussed "whereby clause" to Claims 1 and 13, applicants respectfully request withdrawal of the rejection of Claims 1 - 18 and 21 - 30 under 35 USC § 103(a), over Huffman et al.

Applicants contend that the presently pending claims are in condition for allowance, and the Examiner is respectfully requested to pass the application to allowance. The Examiner is invited to contact applicants' attorney with any questions or suggestions, at the telephone number provided below.

Respectfully submitted,

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